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Drive Disk for High Performance Friction Pairings

The invention relates to a novel construction of drive disks for cable drives and the like, in particular hoists, for improved power transmission.

Main fields of application of the invention are
- hoist drive disks for multiple cable operation,
- drive disks for selectively operable in a single cable mode under lifting loads, such as, for instance,

- cable driven lifting platforms (for instance façade maintenance devices, building scaffolds);
- cable driven vehicles for stationary cable structures (suspension brides, cable suspended roofs, cable cranes, cable cars);
- selective cable car drives;
- selective chair lift drive;
- endless lifting winches for any applications.

A further field of application of the invention are mechanical endless conveyors operating on the traction principle and which satisfy the preconditions of magnetic materials.

The state of the art relating to lift drive disks is characterized by arrangements, the technical realizations of which is based upon Coulomb's law as applied to friction utilizing a homogeneous groove.

Arrangements are known from the claimed field of application of mining shaft conveyors which, while they increase the driving capacity of the cable - drive disk system by groove inserts of different but soft materials, are

unsuited for operating in hoists. About eight decades ago, consideration was given in the mining industry to improving the power transmission by the use of electromagnets.

In this connection, the relevant (German) patent document DE 34 67 27 C discloses the groove of the drive disk wherein the load bearing member is received, to consist of segments structured as pole pieces of an array of electromagnets of alternating polarity the flux path of which between adjacent poles extends through the load bearing member.

In connection with line hauling systems of cable laying ships US patent 3 512 757 discloses the application of magnets in the cable sheaves of winches. In those cases, conventional magnets used which require significant space and added technical complexity and which, therefor, can be used only in single cable operations of large dimensions.

German patent specification DE 33 12 522 A1 discloses a drive disk for particular use in mining, in which in the grooves of the disk rim there is inserted a lining structured as flexible elastic ring having lining elements affixed thereto.

In German patent specification DE 36 26 045 A1, too, there is described a drive disk for mining applications in which along the circular groove of the rim there is arranged a freely movable coating. The coating consists of two layers, i.e. an upper layer of a strip of elastic material and a layer of subdivided into sections connected to each other and in direct contact with the rim. The mentioned sections in this case consist of a (plain) bearing material.

The subject of German patent specification DE 39 23 192 A1 is a drive disk especially for single cable conveyance in mining provided with a drive disk rim in the groove of which coating inserts are arranged at random with a

gap between them. At both their ends, the V-shaped coating inserts are provided, in the direction of movement of the drive disk, with penetrating bores through which a pulling member is fed which is circumscribing the groove.

German patent DE 1,202,587 B describes a reinforcement for use in cable and drive disks for mining applications in which lining materials of a light metal, a hard polymer or the like is affixed to the base body of the of the drive disks and the coefficient of friction and wear resistance of the lining are increased.

German patent DE 1,120,702 B describes a specific lining material for drive disks for shaft conveyors in the mining industry which consists of a specific cast alloy G Al Si. The lining blocks are alternatingly installed on the circumference of the drive disk with lining blocks of thermoplastic polymers or thermoplastic-like polymers.

With prior art inserts in the grooves of drive disk rims known It has been possible to improve wear and frictional behavior of drive disks used in the mining industry. The requisite structural arrangements are complex. In the context of large ratios between the diameter of drive disks and the diameter of cables - greater than about 40 - corresponding applications are conceivable in hoist structures as well. The trend toward light structures will lead to ratios of diameters for hoists into the range of 20 to 30. Increased pressure strains and searing stresses - resulting from uneven cable forces - cause the hitherto known insert materials to fail. In single cable operations, the utilization of force fields to increase the driving capacity is known from the mining field and from hauling winches. However, the arrangements are structurally complex, require large space and increase the systems technology.

It is, therefore, an object of the invention substantially to increase the

forces transmitted from hoist drive disks to the cable to be driven, particularly under extreme stress conditions of the kind occurring at large cable to force ratios and/or small ratios of drive disk to cable. The object includes an analogous increase of the transmission forces in such pairings as drive disk and steel conveyor cable and drive drum and chain, with a simplified structure of related system components.

The object is accomplished in the manner defined in claim 1. Improvements of the invention have been set forth in the subclaims.

As provided by the invention, inlays structured as high-energy magnets from the group of rare earths having energy products of 385 kJ/m^3 are inserted spaced from each along the circumference of groove(s) present in the rim of drive disks. The inserts are sunk into recesses in the groove track in a manner conforming to the surface. This arrangement may be applied to a plurality of adjacent grooves. The arrangement may be supplemented by rim segments between the inlays.

The material used for the above-mentioned drive disk rim or for the rim segments may be the classical drive disk materials such as gray cast iron and the like or, instead, novel compound materials which increase the friction coefficient such as foamed steel materials and fiber composite ceramics which satisfy the requirements regarding compression strength and wear resistance when used in hoist drive disks and similar applications. If rim segments are selected foamed steel materials and/or fiber composite ceramics are the materials preferable used.

This special approach makes it possible to increase Coulomb's friction force since, using fiber composite ceramics, for instance, the values of friction in an idle state reach .4 and, in addition, the normal force from the cable forces is superimposed by a normal force generated by the magnetic forces as a result of the high-energy magnets inserted as inlays at regular

intervals. Hence,

$$F_{uMgn} = \mu_{Mgn}$$

wherein

F_{uMgn} is the tangential resistance force in the area of the magnet effective at the circumference of the drive disk against cable expansion or slippage;

F_{Mgn} is the magnetic gripping force;

μ_{Mgn} the value of friction in the area of the magnet.

The above-mention high-energy magnets are being used which in respect of gripping forces, hardness, shape, wear resistance are to be fabricated as permanent magnets suitable for the individual application. Their arrangement within a given groove track is such that the axis of the magnet and, hence, of the magnetic force, is directed radially.

The inlay segments and, optionally, additional rim segments are distributed over the 360° circumference of the rim of the drive disk with the segments being uniformly spaced from each other by a circumferential angle α. The size of angle α is a function of the desired driving capacity of the pairing drive disk - cable or drive disk - belt.

This technical approach makes it possible to provide frictional values in round grooves which correspond to those of V-belts at a defined cross-sectional angle and attainable state of wear, but which, in contrast to the V-groove or an undercut round groove ensure a significantly reduced wear of the groove (lower compression) and long cable life relative to a given design. To satisfy extreme demands, of the power transmission, for instance, the teachings of the invention may also be applied to other shapes of grooves, in particular round undercut grooves.

Optimization of the design of the drive disk relative to

- the magnetic gripping force, the geometric shape of the high-energy

permanent magnets, the definition of further physical parameters, the arrangement of the magnets on the one hand and/or

- structuring of the rim of the drive disk of gray cast iron, polymers and the like, foamed steel or compound ceramics on the other hand

is selectively carried out in accordance with a given technical purpose.

The arrangement requires a modified approach to Eytelwein's equation

$$F1/F2 * \varphi (p) \leq e^{\mu\beta}$$

where

F1, F2	: cable forces;
φ (p)	: delay factor;
e	: base of natural logarithm;
μ	: apparent value of friction;
β	: geometric arc of conduct.

If the drive disk described in its structure is widened in its axial direction, the result will be a drive drum for mechanical endless conveyors, the basic structure of which is structured like a drive disk wherein the arrangement of rim segments (5) and inlays (6) have been widened in the axial direction, i.e. over the width of the drive drum.

The advantages connected with the patent are multifarious, i.e., among others:

- increase of Coulomb's friction force by raising μ^{System} as a result of using fiber composite ceramics or foamed steel materials and the like;
- superposing Coulomb's friction force with a magnetic friction force - generated by high-energy magnets from the group of rare earths;
- selective design of the drive disk for low wear transmission of large circumferential forces of transmission of very large circumferential forces for special applications.

A significant increase of the drive capacity of round grooves in particular was attained.

The transmission of force is significantly improved by the measures mentioned, the secondary consequences connected therewith are:

- savings in the mass of the cable drive by an enlarged and technically transferrable F1/F2 ratio, possibility of extremely light construction in hoist technology;
- possible reduction of the required diameter of the drive disk;
- reduction of the cable diameters as a result of reduced strain or load in view of the fact that wear as a result of expansion or slippage at the drive disk are substantially reduced;
- because of the smaller diameter of the drive disk, smaller drives by increased rotations of the drive disk;
- reduction of the required energy, always connected with associated economic advantages.

Further details, characteristics and advantages of the invention may be gleaned from the ensuing description of an embodiment with reference to the drawings in which:

Fig. 1 depicts the structure of the drive disk rim with rim segments of fiber composite ceramics arrayed between the inlays of high-energy magnets;

Fig. 2 shows a groove segment made of a material different from the remainder of the groove rim. In a different construction, this material may be used for the entire rim in which the bores for receiving the high-energy magnets would be formed;

Fig. 3 depicts the design of a drive disk for high efficiency friction pairings in which high-energy magnets are inserted as inlay segments into the groove tracks of the drive disk rim.

Fig. 1 depicts an exemplary array of rim segments 5 and, optionally, inlays 6 over the 360° circumference of the drive disk rim 2. The rim segments 5 are arrayed, spaced from each other by circumferential angle α, in every groove track 3 (see section A-A). Alternatively, the may in the axial

direction be formed of one piece inserted into all groove tracks 3.

To achieve a predetermined drive capacity of the drive disk, other arrays, constructions and distribution densities of inlay segments 6 (high-energy magnets) over the circumference of the drive disk rim 2 may additionally or exclusively be selected..

Fig. 2 shows a detail B of the exemplary geometry of a rim segment 5. The shape of the groove 3 is defined by its radius of curvature, d corresponding to the diameter of the cable 4. The dimensions of the width b and height h of the rim segment 5 correspond approximately to twice the diameter d of the groove, i.e. $b = h \sim 2d$. The length l of a rim segment 5 is at least thrice the diameter d of the cable, i.e. $l \sim 3d$.

Fig. 3 depicts the design of a drive disk for high efficiency friction pairings with high-energy magnets 6 inserted as inlay segments analogously to Fig. 1. The high-energy magnets 6 are of cylindrical shape (see detail C) and are of the following dimensions for height h and diameter d_M of the magnets: $h \sim 25 - 35$ mm; $d_M \sim 20 - 32$ mm. The polarity is indicated as well. At present, such magnets achieve gripping forces of 42 - 700 N.

The material of the base body 1 and the drive disk rim 2 used in both embodiments is traditional grey cast iron. The rim may, if high-grade materials such as foamed steel, fiber composite ceramics and the like are being used, be fabricated separately and connected to the base body in a suitable manner.

List of Reference Characters

1	drive disk wheel body
2	drive disk rim
3	grooves, groove track

4 wire cable

5 rim segments

6 inlays (high-energy magnets)